Glider Observations of Upper Ocean Structure in the Bay of Bengal

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LONG-TERM GOALS

The Bay of Bengal (BoB) is remarkable in that its major currents change directions seasonally with the monsoons, in concert with extremely strong fluxes of fresh water from precipitation and river input. The overarching goal of the proposed effort is to quantify important processes in the fresh water budget of the BoB, including the effects of submesoscale processes and internal waves.

OBJECTIVES

The extreme fresh water input in the BoB poses challenges scientifically and technically, because of the existence of a fresh, light surface layer. We advance a program with two major objectives, one scientific, and one technical:

- Observe the evolution of upper ocean structure in the central Bay of Bengal using gliders and floats
- Improve glider technology to overcome fresh, buoyant surface layers

APPROACH

We use two approaches to observe the upper ocean in the BoB. First, we deploy Spray underwater gliders to resolve simultaneously vertical and submesoscale horizontal structure in the BoB. Second, we deploy floats in two modes: rapidly profiling to observe high-frequency phenomena, and with a 5-day repeat to contribute to the large-scale Argo observations in the BoB.

WORK COMPLETED

SOLO-II profiling float 8119 was deployed at 1330Z 21 November 2013, at 16.23°N, 86.96°E. During the first part of its mission, the float profiled continuously between the surface and 250 m, with a cycle taking about 100 min. Profile 229 at 1732Z 07 December 2013 at 17.07°N, 84.44°E was the end of continuous profiling. At this time, the float began parking at 1000 m, and profiling to 2000 m every 5

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days. Two additional SOLO-II floats (8134 and 8134) were deployed during the November Revelle cruise; these continue missions of profiles to 2000 m every 5 days.

In collaboration with J. Moum and E. Shroyer (Oregon State University), we mounted a chi-pod on a SOLO-II float (8250) with a goal of measuring thermal dissipation in the upper 50 m. The float was deployed from the R/V Revelle at 1154 20 June 2014 at 13.06°N, 84.75°E, with a mission of profiling to 50 m every 35 min. The last communication was from the dive that ended at 0846 21 June 2014, 13.22°N, 85.20°E. The float was lost at this time, likely because it was hit by the vessel, or the UCTD line or probe being towed at the time.

Engineering effort has been directed towards improving Spray glider behavior when encountering a buoyant surface layer. First, the gliders used in the BoB were outfit with larger bladders that allow for 20% more buoyancy change than our standard bladder. Second, we developed smarter software to take appropriate actions in case the glider cannot reach the surface. These actions include pumping more oil to increase buoyancy, continuing to profile even without being able to communicate at the surface, and finally heading for a safe waypoint predetermined to be in less buoyant water. These developments proved successful during two glider missions over the past year.

Two glider missions were completed during the year. Spray 24 was deployed on 14 November 2013 and recovered on 19 June 2014 for a duration of 217 days, with both operations from the R/V Revelle. Spray 24 completed 529 dives to as deep as 1000 m, covering 2728 km over ground and 2841 km through water. The mission consisted of a transit from the deployment location at 15.17°N, 86.10°E to 17°N, 88°E, then a long line southward to 9°N, 88°E. At this time, to extend the mission length, the glider began drifting at depth thus conserving battery. The glider was piloted to the operations are of the R/V Revelle in June for recovery. Spray 26 was deployed on 19 June 2014 upone recovery of Spray 24. Spray 26 transited to the southern end of the long line at 9°N, 88°E, then proceeded northward. Unfortunately, the CTD failed about one month into the mission. The glider was recovered by the R/V Sagar Nidhi on 25 August 2014 after a mission of 68 days, having done 336 dives to as deep as 1000 m, covering 1601 km over ground and 1753 km through water. While the entire long line was completed, the CTD was functioning well only over the southern part of the line.

RESULTS

The results from SOLO-II float 8119 showed a remarkable transition from an upper ocean dominated by tidal flow to a near-inertial oscillation (Figure 1). These data comprise a textbook example for the application of wavelets to demonstrate the change in frequency content with time. The polarization of the tidal flow was mostly clockwise, consistent with a tidal internal wave. The inertial motion was entirely clockwise and circular, and it began with a burst of clockwise inertial wind forcing.

The long glider line occupied from 2 December 2013 through 19 January 2014 showed the large scale structure in the BoB (Figure 2). Fresh pools of water in the north are typical of this time of year. The horizontal separation between profiles was about 6 km. Further analysis will focus on submesoscale variations in temperature and salinity. Gliders are especially useful for studying these variations in spice on isopycnals where internal wave effects are intrinsically filtered. The results are relevant to isopycnal stirring as we have demonstrated in a number of recent publications (Rudnick et al., 2011; Todd et al., 2012; Cole and Rudnick, 2012).

IMPACT/APPLICATIONS

An anticipated impact of this work will include improved technology for buoyancy-driven platforms in a buoyant surface layer. All temperature and salinity data from Spray gliders were sent to NAVO in real time for assimilation into operational models. All data from SOLO-II floats were publically distributed through Argo.

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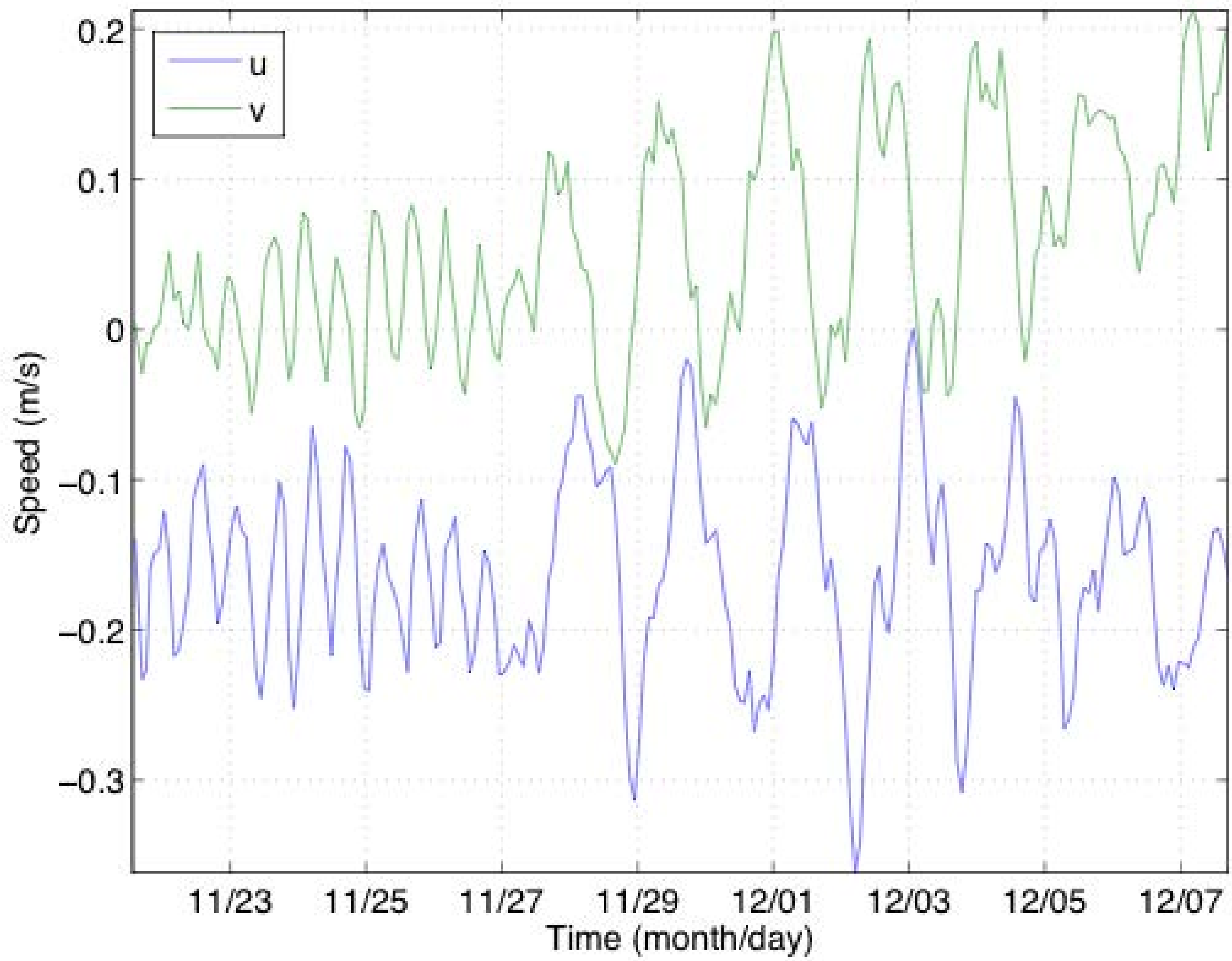

Figure 1. Eastward (blue) and northward (green) velocity of SOLO-II float 8119. Velocity is calculated from GPS positions just before diving and just after surfacing, and so represents the average velocity over the complete dive cycle. As the dive and ascent speeds are nearly uniform, this is essentially a depth-average velocity over the upper 250 m. Mean velocity was roughly 0.2 m/s westward. An oscillation with a semidiurnal period was apparent until 11/27, when an inertial signal began to dominate. The inertial period at 16.5° is 42 h.

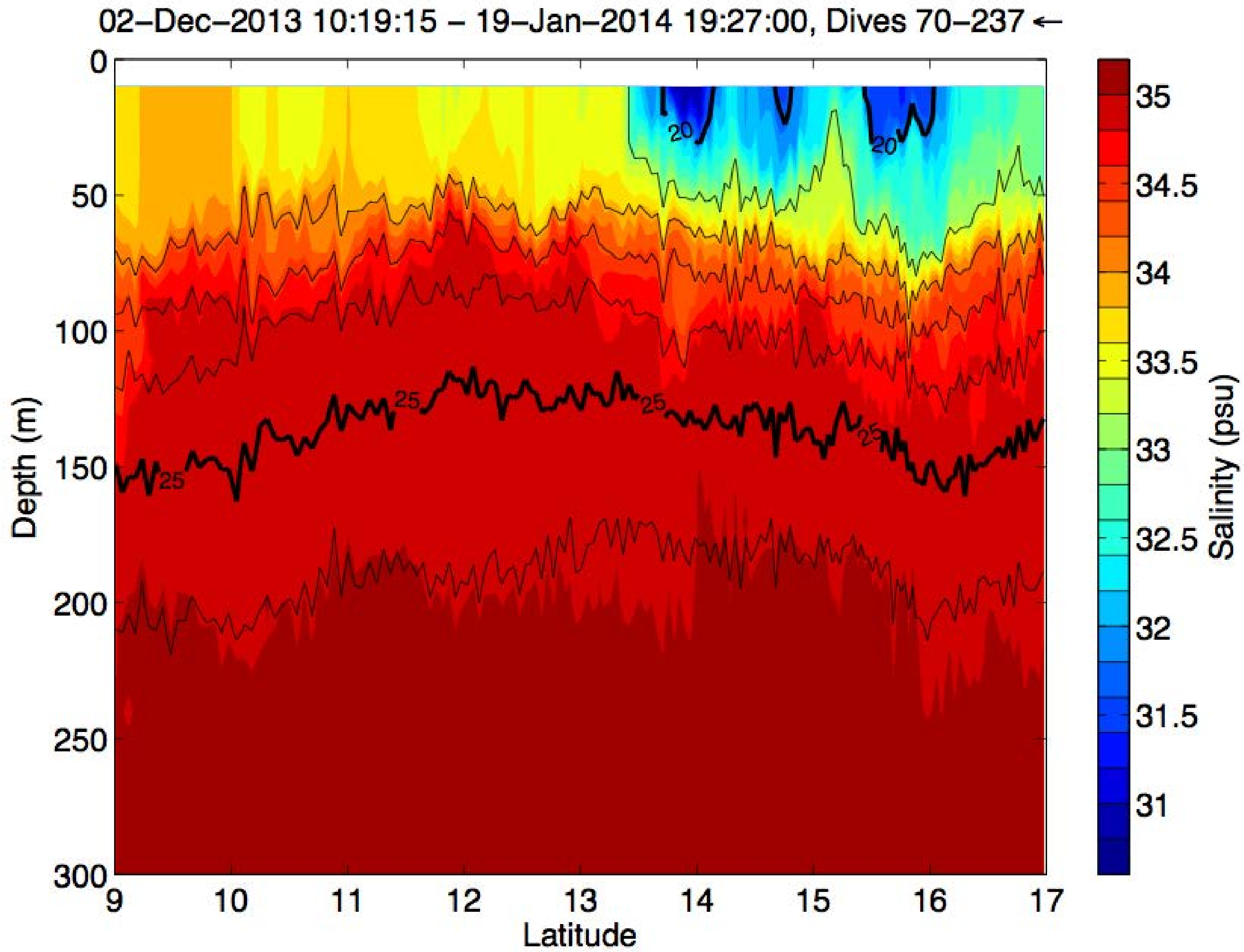

Figure 2. The upper 300 m of the Spray glider section between 9-17°N along 88°W. The line was done north to south. Color shading is salinity and black lines are isopycnals. Fresh pools of surface water are evident in the north, consistent with typical BoB conditions at this time of year.